IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RE: Application No: 10/520,358

Applicant: **Andreas BARTH**

Filed: June 23, 2005 as national phase of International Application No. PCT/EP2003/006727, filed June 26, 2003

Entitled: **AS-MAGNESIUM PRESSURE DIE CAST ALLOY AND METHOD FOR PRODUCING A SUBASSEMBLY PART FROM AN AS-MAGNESIUM PRESSURE DIE CAST ALLOY OF THIS TYPE**

Art Unit: 1793

Examiner: Sikyin IP

Docket No. 510.1122

Confirmation No.: 5923

Customer No: 23280

July 15, 2008

Declaration pursuant to 37 C.F.R. § 1.132

S I R:

I, Clint Mehall, an attorney representing Daimler AG, the assignee of the invention in the above mentioned patent application, declare as follows:

The following documents, which are enclosed herewith, were provided to me by my client, Daimler AG:

1) Copy of the presentation "Mg-Application in the 7G-Tronic-Gear" by the inventor, Andreas Barth, at the 61st Annual World Magnesium Conference, May 9 to 12, 2004, in New Orleans, Louisiana USA (13 pages);

2) Copy of "Proceedings: 61st Annual World Magnesium Conference," May 9 to 12, 2004, New Orleans, Louisiana USA, including the cover, table of contents and "Mg-Application in the 7G-Tronic-Gear;" (7 pages: cover, i, 81 to 85);

3) Copy of abstracts of the 61st Annual World Magnesium Conference featured on the internet at www.intlmag.org (5 pages).

The documents include evidence supporting arguments in the traverse of the rejections in the Office Action dated April 4, 2008.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and, further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued hereon.

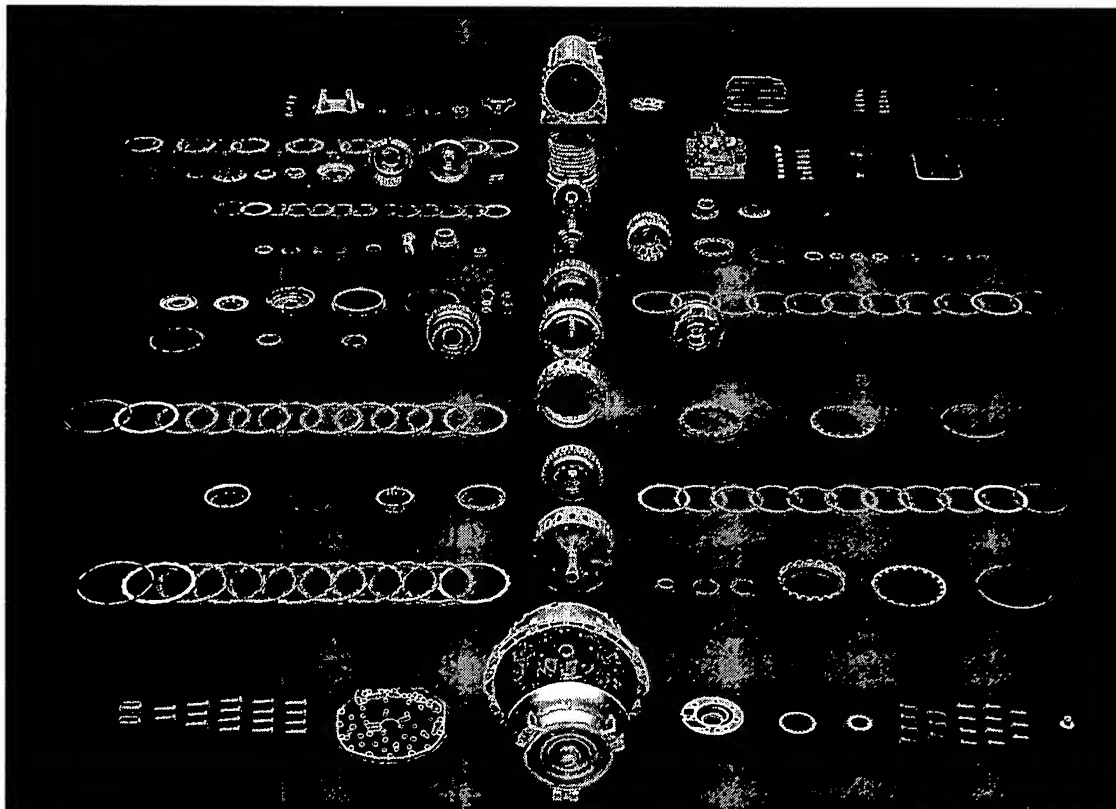
Date: July 15, 2008

Clint R. Mehall, Reg. No. 62,380

Mg-Application in the 7G-Tronic-Gear

Dr.-Ing. Andreas Barth

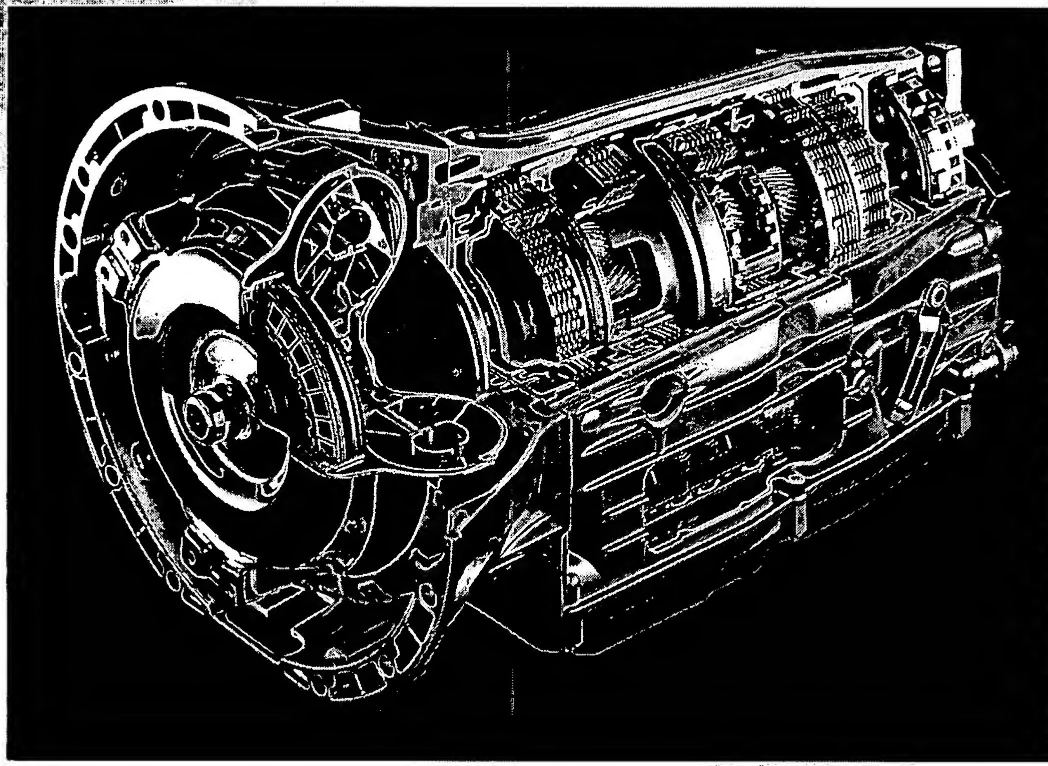
61-st IMA-conference 9-12 th May 2004, New Orleans

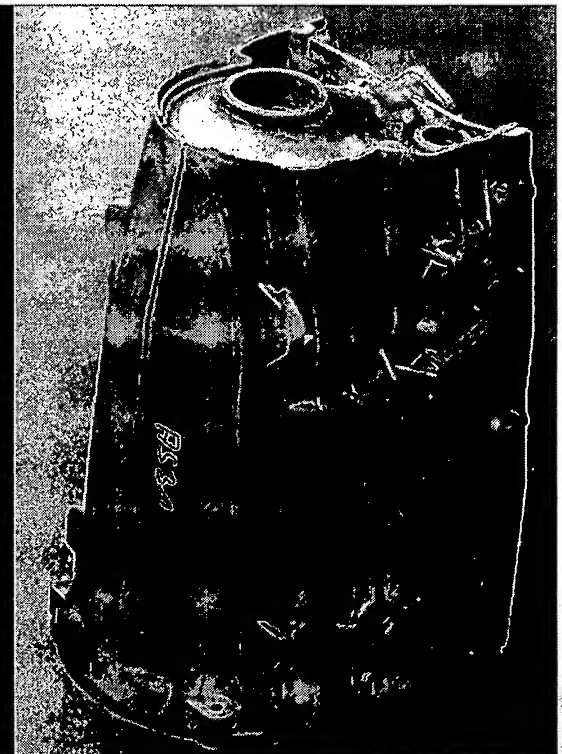


Light weight major units and components

DAIMLERCHRYSLER

1. Benefits of a Magnesium-transmission case (gear box)





1) Compared to Al a 25 % lighter Mg-die casting-gear-case with small extra-costs

2) With respect to the high torque- (700 Nm) and thermal stress (up to 150°C) in the 7 G-Tronic-gear box new Mg-process engineering-concepts had to be developed

2. Former problems for the application of Mg-gear-boxes

a) Former high Mg-alloy-prices (> 1,25 USD/lbs)

b) Cast-ability of creep-resistant AS-alloys (casting-die soldering, hot cracking)

- gear-box-casting-technology
- alloy-modification AS 31
- special die-lubricants

c) Availability of mechanical & thermal material data

- dependent on the cooling-condition after casting
- dependent on thermal stress at 150°C

d) Fastener-technology (bolt load retention)

e) Corrosion resistance & corrosion protection

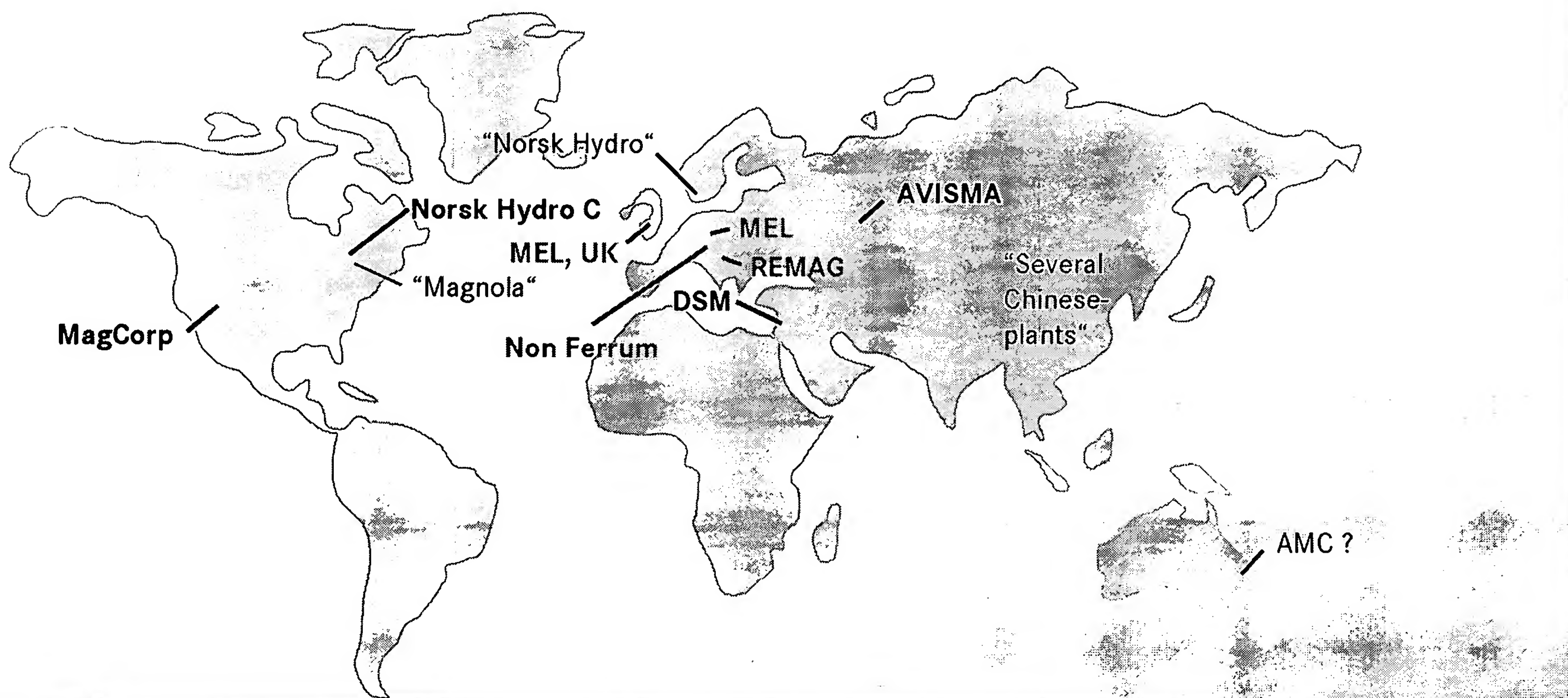
f) Machining of ductile Mg-alloys

g) Recycling-concepts for critical foundry-dross and turnings

3. Found solutions at DCX

a) In comparison to Aluminum competent Mg-alloy-prices by:

- Worldwide Mg-Marketing-Strategy with DCX-purchase department for the selection of high-quality & low price primary and secondary Mg-producers
- Internal and external Recycling-concepts (casting-residual & chips)

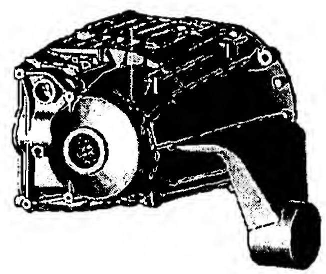


Light weight major units and components

DAIMLERCHRYSLER

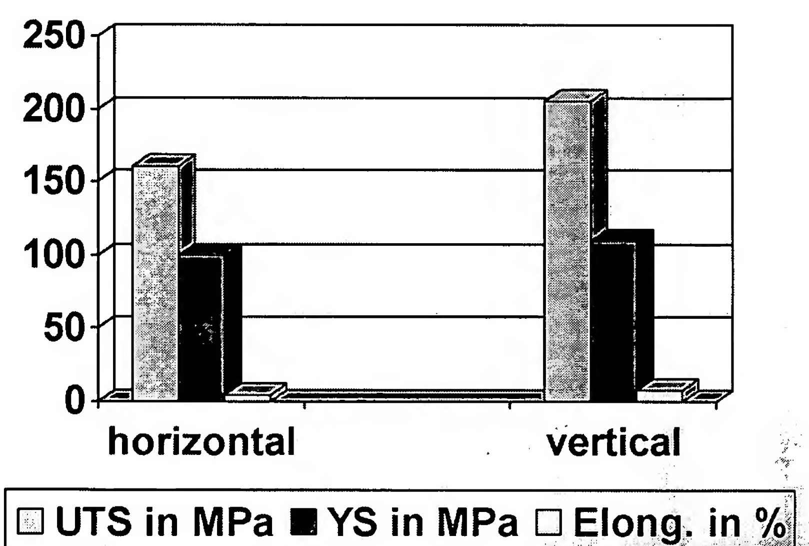
b) Cast-ability of AS-die-casting-alloys is guaranteed by

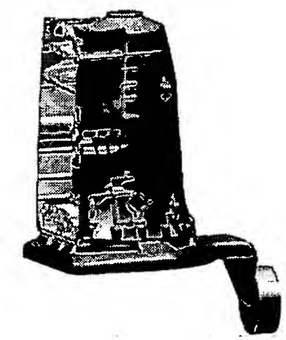
- Al-content higher than 2,5 wt.-% (no sticking or hot cracking)
- Special die lubricants and high die-mold-temperature (no sticking)
- Vertical casting (see below)



Left: Former horizontal casting of Al-gear-boxes (pores, oxides)

AS 31-strength-values due to casting-method

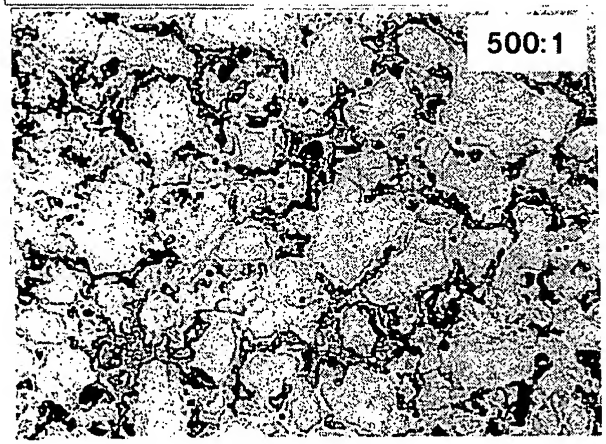




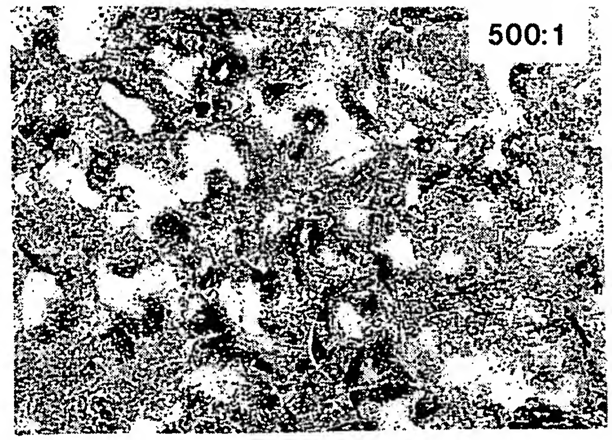
Right: For Al and Mg correct vertical casting

c) Microstructure: Thermal aging of air-cooled Mg-gear-boxes

$Mg_{17}Al_{12}$-phases in AZ 91 HP as cast

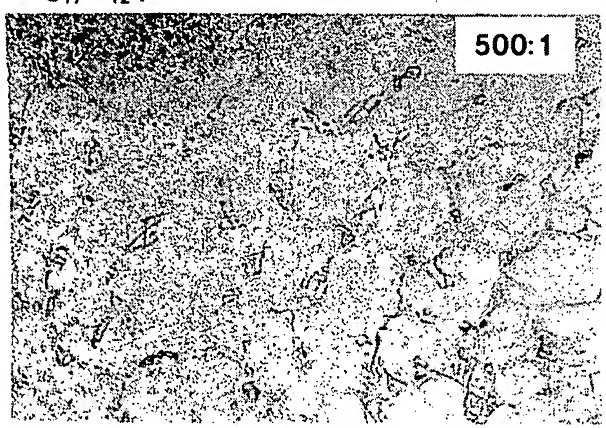


and in AZ 91 HP after 2000 hr aging at 150°C

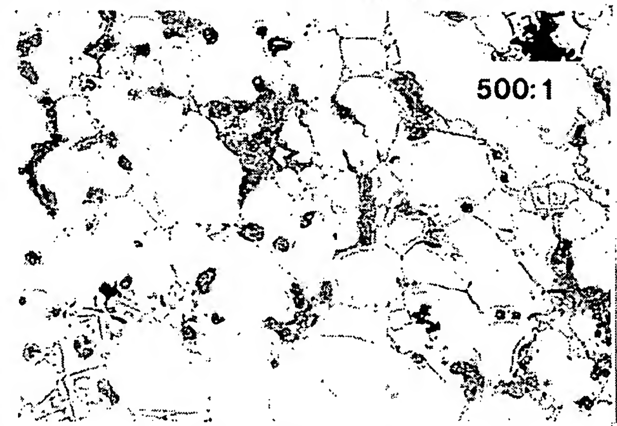


Above: Microstructure of an AZ 91 HP-gear-box

$Mg_{17}Al_{12}$-phases in AS 31 HP as cast



and in AS 31 HP after 2000 hr aging at 150°C

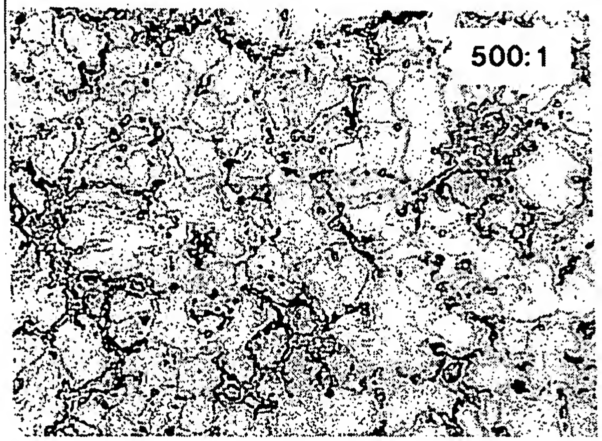


Below: Microstructure of an AS 31 HP-gear-box

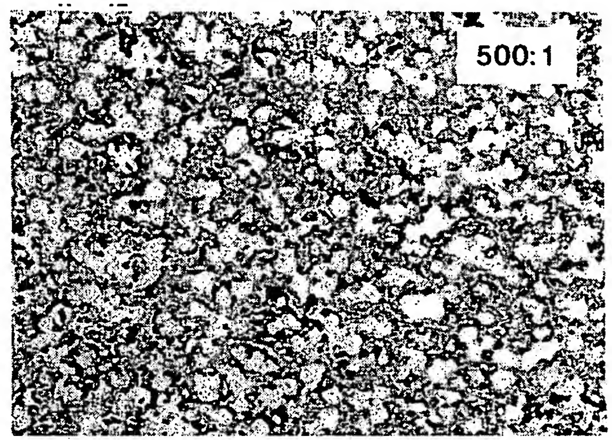
In case of air-cooled AZ 91- and AS 31-gear boxes coarse $Mg_{17}Al_{12}$-phases are formed after thermal aging (increase of the upper yield-strength and material-embrittlement)

c) Microstructure: Thermal aging of water-quenched Mg-transmission case

$Mg_{17}Al_{12}$-phases in AZ 91 HP as cast

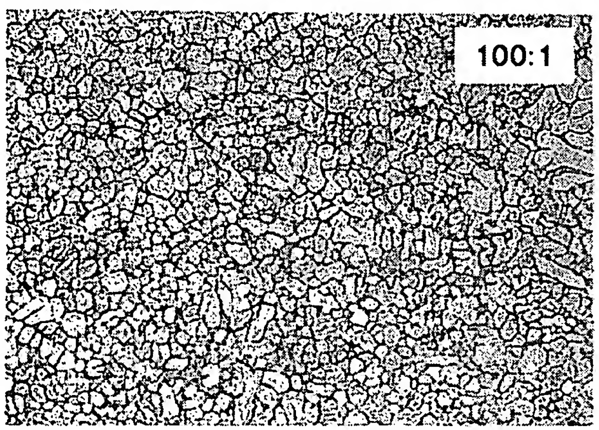


and in AZ 91 HP after 2000 hr aging at 150°C

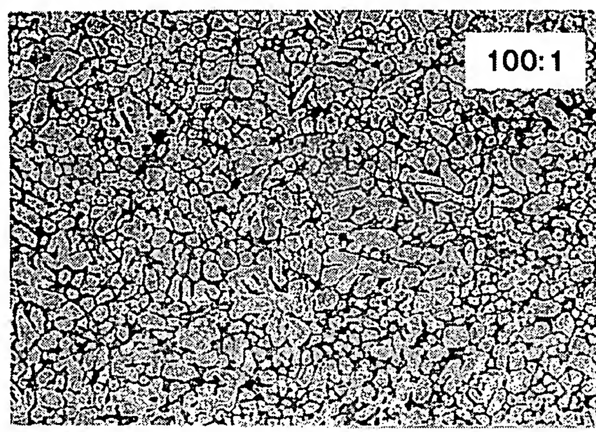


Above: Microstructure of AZ 91 HP-gear-box

$Mg_{17}Al_{12}$-phases in AS 31 HP as cast



and in AS 31 HP after 2000 hr aging at 150°C



Below: Microstructure of an AS 31 HP-gear-box

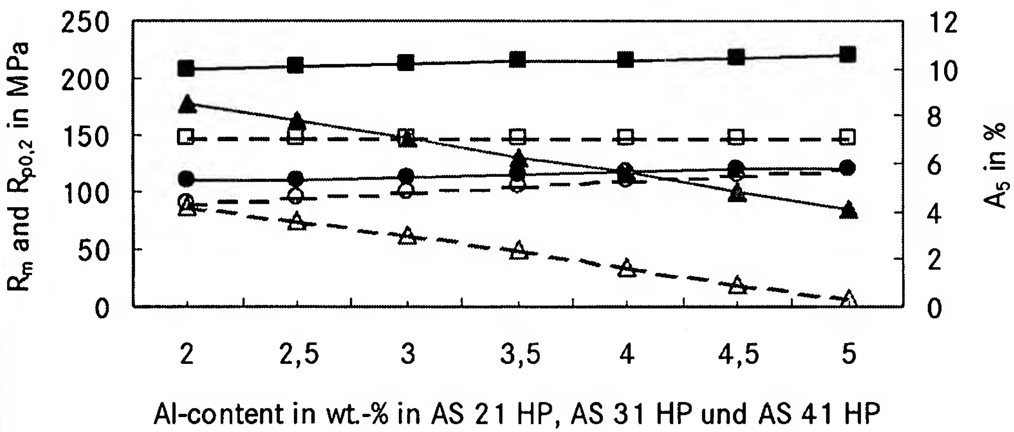
In case of water-quenched AZ 91-/AS 31-gear boxes fine $Mg_{17}Al_{12}$-phases are formed after thermal aging (increase of the upper yield-strength by only small material-embrittleness)

Light weight major units and components

DAIMLERCHRYSLER

c) Strength of water-cooled AS-boxes as cast and after 2000 hr aging at 150°C

Mechanical properties as cast:



Mechanical properties depending on the Al-content in AS-gear cases in the cast-feed-zone (line) and cast-evacuation-zone (dotted line)

Agenda: ■ : upper tensile strength R_m

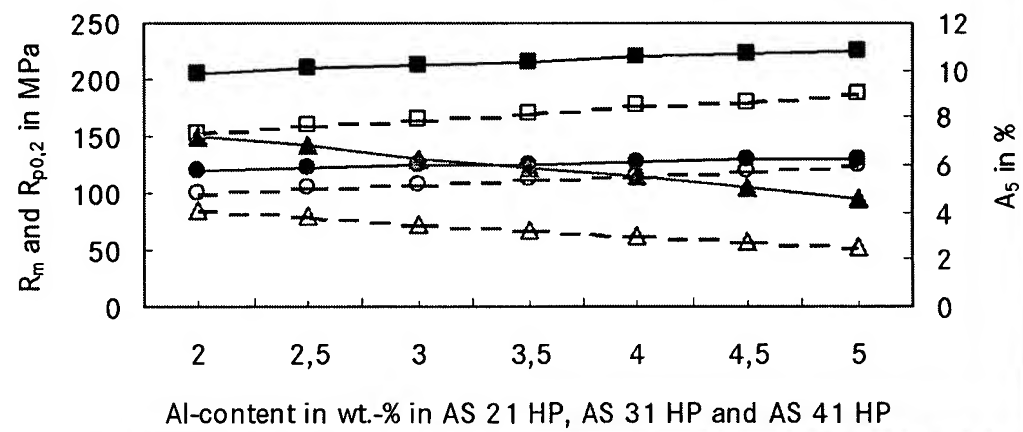
● : yield strength $R_{p0,2}$

▲ : fracture-elongation A_5

Remarks:

- **Higher Al-content improves the strength but lowers ductility**
- **Better mechanical properties in the cast-feed-zone**
- **Long term aging at 150°C:**
  - 10 MPa increase of the yield-strength
  - 1 up to 2 %-loss of fracture-elongation

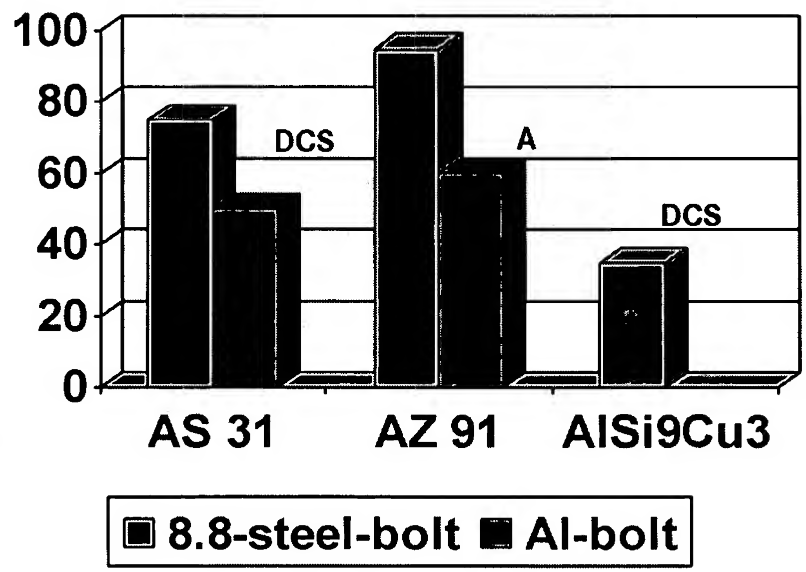
Mechanical properties after 2000 hr aging at 150°C:



Light weight major units and components

d) Fastener-technology (bolt-load-retention, not creep-resistance !)

Bolt-load-retention-tests (5 cycles for 100 hr at 140°C and for 10 hr at 150°C):



DCS: Former DCS-transmission case in Al (A 226, equivalent to A 380)

DCS: 7 G-TRONIC-gear-box in AS 31 HP

A: Gear-box in AZ 91 HP

⇨ As Al-bolts have a similar thermal expansion-coefficient to Mg, the bolt load retention during drive-service is a lot of higher than that of steel-bolts

Cost-neutral Al-bolts ! (volume-price/shorter length/cost effective bolt-production)

e) Corrosion-resistance & corrosion-protection

Corrosion tests were carried out:

1 week cyclic climate-test with a maximum temperature of 120°C, followed by a VDA-test (page 621-415) for 1 week

e 1) Avoidance of surface-corrosion:

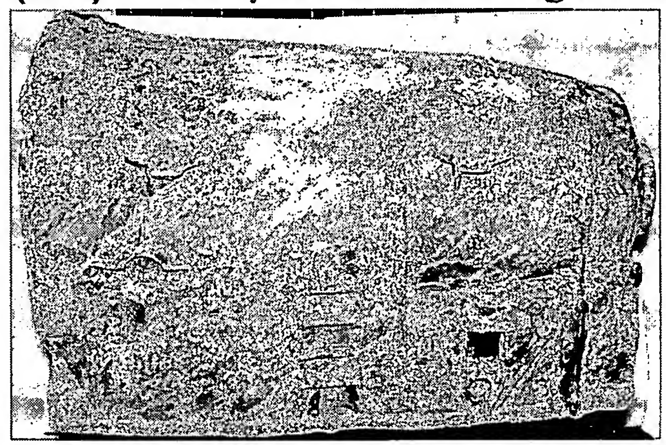
- High purity quality
- Fe/Mn- and Cu/Zn-ratios
- Al-content in Mg-alloys of least 3 wt.-%
- Special capsule-design
- Application of special die-casting lubricants leading to a hydrophobic Mg-surface *(lubricant burns inside the skin of the die-casting and is not removed by clean- blasting, high-pressure water-stream-cleaning and clean-washing)*

Light weight mayor units and components

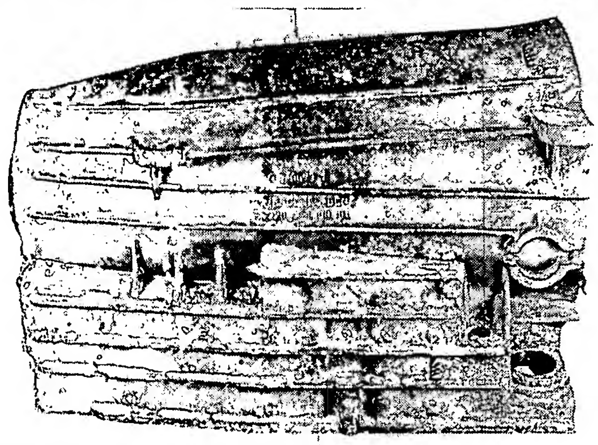
DAIMLERCHRYSLER

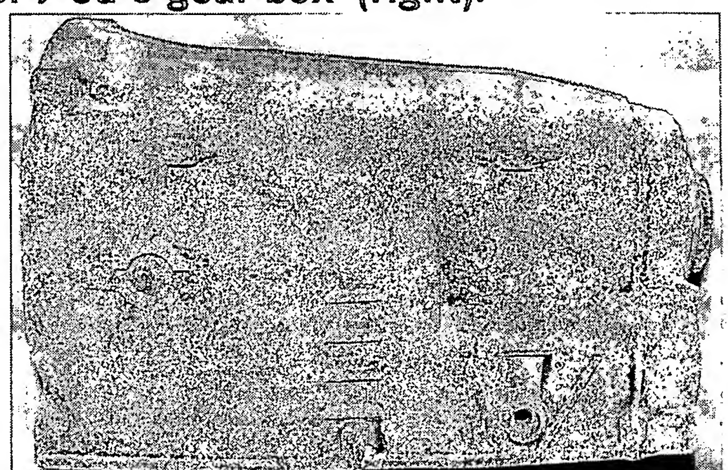
e1) *Avoidance of Surface-corrosion*

Corrosion-behavior of a preserved AS 21 *HP*- (left) and *Ni-polluted* AS 21-gear-box (right):



Corrosion-behavior of a preserved AS 31 HP-gear-box (left) and a non preserved and with Ferrosat *blasted* A 226- or GD-Al Si 9 Cu 3-gear-box (right):

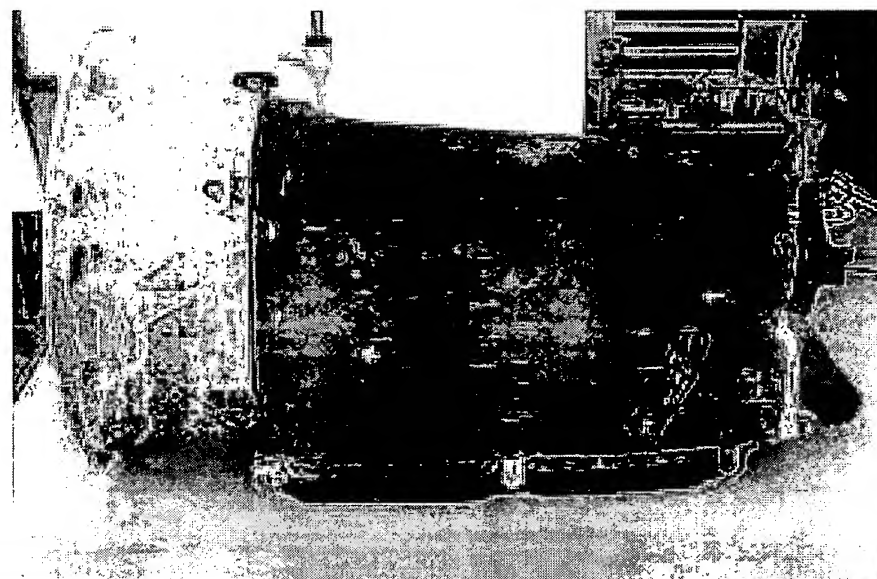




Light weight major units and components

e 2) __Avoidance of contact-corrosion:__

- **Correct die-lubricants**
- **Cast-cleaning with non-steel-tools & blasting with Al-granules**
- **Al-bolts with limited Cu-content**
- **Seals between the Mg-gear-box/A 226-major units-parts**



Light weight major units and components

f) Machining of ductile AS 31 HP-transmission case (gear-box)

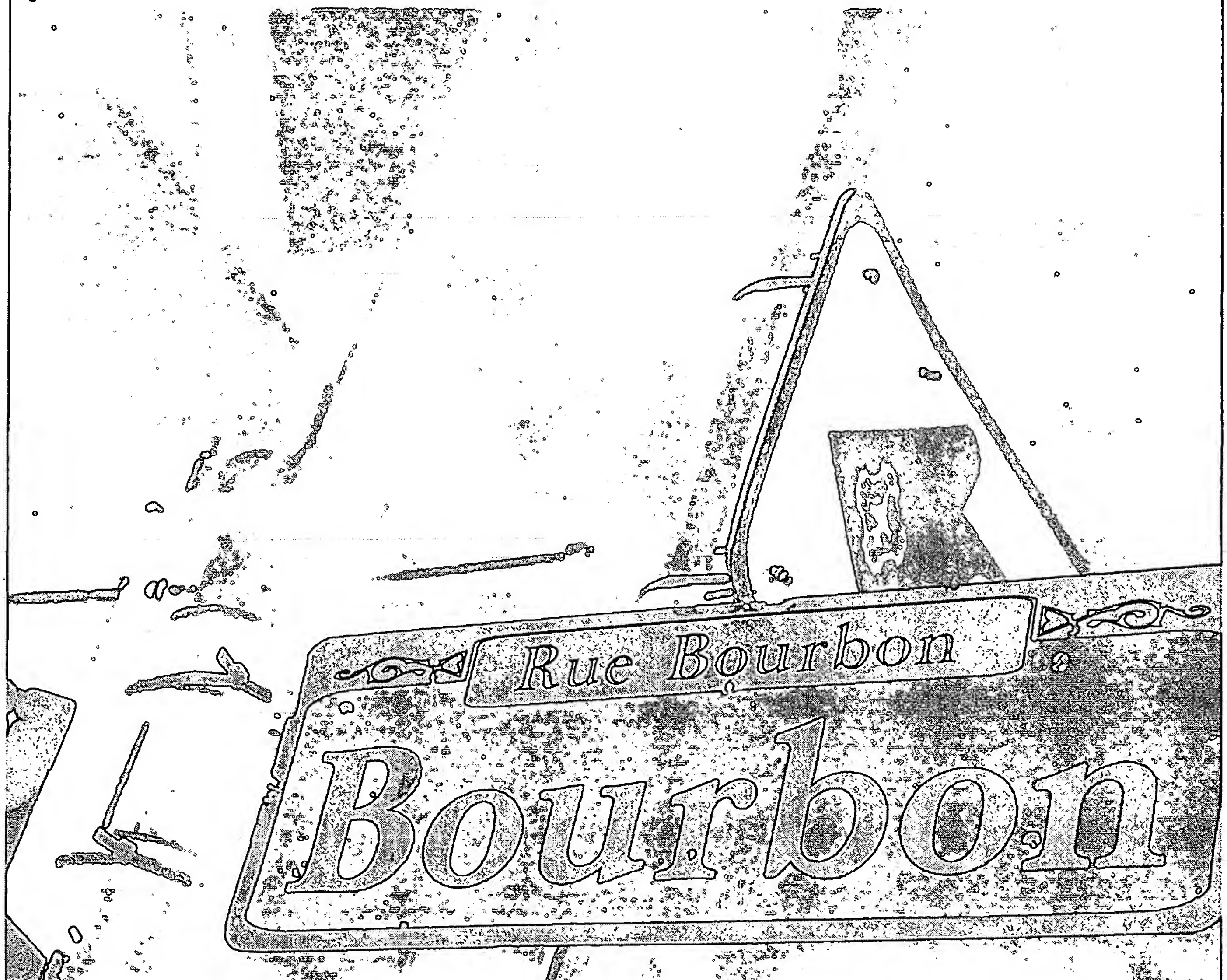
- Observance of the tolerances is o.k.
- Formation of longer chips and a build-up of chips, retaining on Mg-transmission case (gear box) requires (machining of ductile metal-alloys):
  - Geometry-optimization of the machining-tools
  - High machining velocities
- Removal of retained turnings/chips by high-pressure water streams

g) Recycling-concepts for critical foundry-dross and turnings

- Only by external recycling (degassing, removal of oxides)
- Special refining-technologies (skill of very few recycling-specialists)
- Special ratios between cast-scrap/dross/turnings

➡ ***Future-target of the Mg-raw-material industry !***

PROCEEDINGS



61st Annual World Magnesium Conference

May 9 - 12, 2004

Omni Royal Orleans Hotel
New Orleans, Louisiana USA

International Magnesium Association
www.intlmag.org

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Mg-Application in the 7G-Tronic-Gear

Dr.-Ing. Andreas Barth

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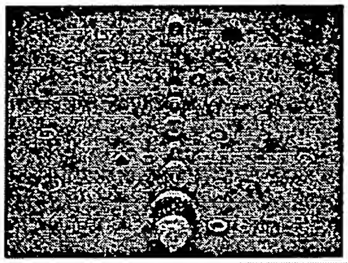

PWT/VEW Dr.-Ing. Barth

Light weight major units and components

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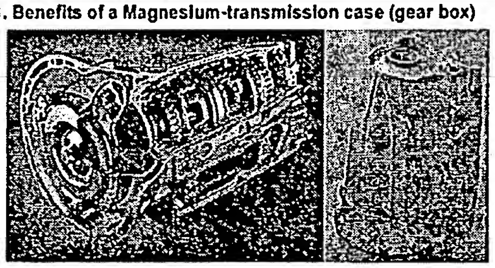

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2) With respect to the high torque- (700 Nm) and thermal stress (up to 150°C) in the 7 G-Tronic-gear box new Mg-process engineering-concepts had to be

Light weight major units and components

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a) Former high Mg-alloy-prices (> 1,26 USD/lbs)

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- gear-box-casting-technology
- alloy-modification AS 31
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c) Availability of mechanical & thermal material data
- dependent on the cooling-condition after casting
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d) Fastener-technology (bolt load retention)

e) Corrosion resistance & corrosion protection

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Light weight major units and components

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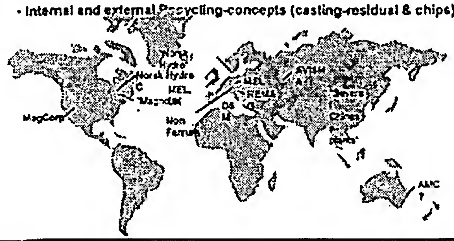

Light weight major units and components

b) Cast-ability of AS-die-casting-alloys is guaranteed by

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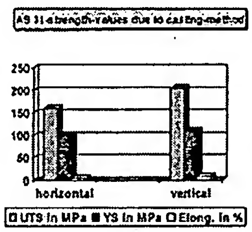
- Vertical casting (see below)

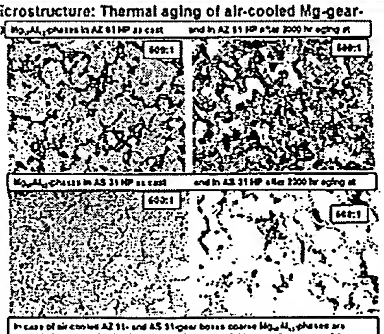
Left: Former horizontal casting of Al-gear-boxes (pores, oxides)



Right: For Al and Mg correct vertical casting

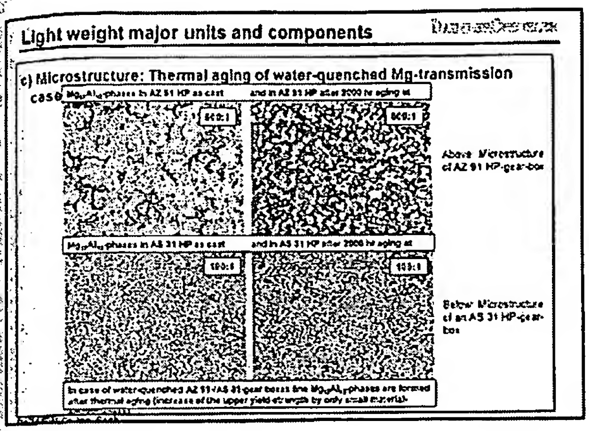
Light weight major units and components

c) Microstructure: Thermal aging of air-cooled Mg-gear-box



Above: Microstructure of an AZ 91 HP-gear-box

Below: Microstructure of an AS 31 HP-gear-box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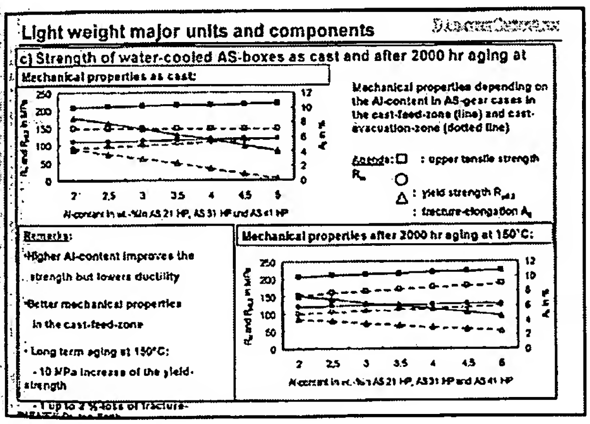
Light weight major units and components
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Mechanical properties as cast:
Mechanical properties depending on the Al-content in AS-gear cases in the cast-feed-zone (line) and cast-evacuation-zone (dotted line)
upper tensile strength
fracture-elongation
Remarks:
Higher Al-content improves the strength but lowers ductility
Better mechanical properties in the cast-feed-zone
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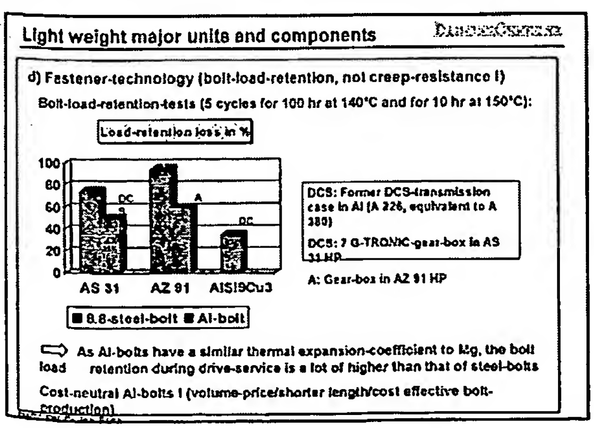
- 10 MPa increase of the yield-strength
Mechanical properties after 2000 hr aging at 150°C:


Light weight major units and components
d) Fastener-technology (bolt-load-retention, not creep-resistance !)
Bolt-load-retention-tests (5 cycles for 100 hr at 140°C and for 10 hr at 150°C):
Load-retention loss in %
100
80
60
40
20
0
AS 31
AZ 91
AlSi9Cu3
8.8-steel-bolt
Al-bolt
DCS: Former DCS-transmission case in Al (A 226, equivalent to A 380)
A: Gear-box in AZ 91 HP
As Al-bolts have a similar thermal expansion-coefficient to Mg, the bolt load retention during drive-service is a lot of higher than that of steel-bolts
Cost-neutral Al-bolts ! (volume-price/shorter length/cost effective bolt-production)

3

Light weight major units and components

e) Corrosion-resistance & corrosion-protection

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1 week cyclic climate-test with a maximum temperature of 120°C, followed by a VDA-test (page 621-415) for 1 week

e 1) Avoidance of surface-corrosion:

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- Al-content in Mg-alloys of least 3 wt.-%
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(lubricant burns inside the skin of the die-casting and is not removed by clean- blasting, high-pressure water-stream-cleaning and clean-washing)

Light weight mayor units and components

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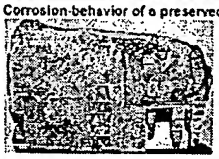
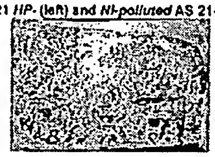
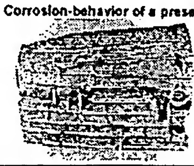
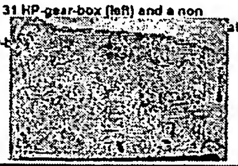




Corrosion-behavior of a preserved AS 31 HP-gear-box (left) and a non



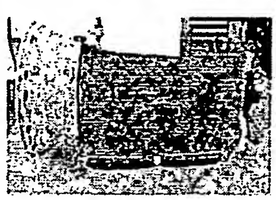
-gear-



Light weight major units and components

e 2) Avoidence of contact-corrosion:

- Correct die-lubricants
- Cast-cleaning with non-steel-tools & blasting with Al-granules
- Al-bolts with limited Cu-content
- Seals between the Mg-gear-box/A 226-major units-parts



Light weight major units and components

f) Machining of ductile AS 31 HP-transmission case (gear-box)

- Observance of the tolerances is o.k.
- Formation of longer chips and a build-up of chips, retaining on Mg-transmission case (gear box) requires (machining of ductile metal-alloys):
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- Only by external recycling (degassing, removal of oxides)
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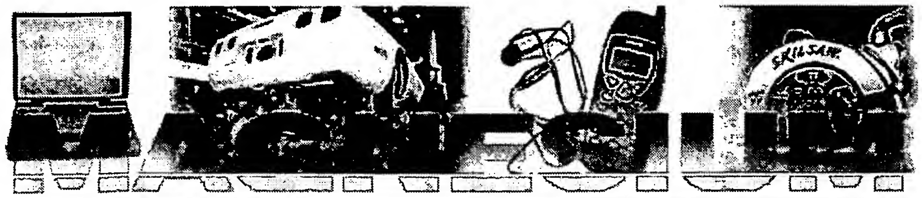
- Special ratios between cast-scrap/dross/turnings

⇨ *Future-target of the Mg-raw-material industry !*



INTERNATIONAL MAGNESIUM ASSOCIATION

2004 Abstracts

"Magnesium Supply & Demand"
Tim Pretzer, Timminco Ltd
Author will present published data as supplied by the International Magnesium Association regarding historical supply and demand for magnesium. Perspectives will also be offered regarding requirements for successful capacity growth in the future relative to cost, capital, political and infrastructure issues.

"Advances in China's Magnesium Application Market"
Meng Shukun and Wu Xiuming, China Magnesium Association
China magnesium industry with Pidgeon Process has achieved new developments in recent 10 years in technology, process, equipment, technical & economical indexes and product developing and application as well. The paper also analyses the existing problems on environmental protection and utilization of energies. The authors propose that the future development of China magnesium industry should not rely on export, not only produce primary magnesium products, but develop and produce high value added magnesium products for export; should focus on the domestic market, enforce application of magnesium alloy, promote and push the development of domestic magnesium application market, encourage and support foreign enterprises to come to China and set up factories via joint venture and cooperation, take use of foreign advanced technology, equipment and China resources and labor to produce high end products, expand domestic demand for magnesium products besides exporting, strengthen its competitive edge in the international market.

"Advances in Magnesium Alloy Development"
Hakon Westengen and Per Bakke, Magnesium Competence Centre, Hydro Aluminum; Daryl Albright. Hydro Magnesium Market Development
Considerable effort has been made over the last decade to develop new magnesium die cast alloys. This has resulted in a series of new alloy compositions, targeting demanding market segments, in particular automotive applications. A prerequisite for success in the market is the fulfillment of the specific material properties required by the applications, however, a series of other technical and economical factors need to be fulfilled to make the new alloy a market success. The present paper discusses recent new alloy developments from a basic material angle, and points out further challenges. Main emphasis will be on die casting alloys for elevated temperature use as well as crash sensitive applications. Important aspects related to the overall value chain are discussed.

"Evaluation of High Temperature, Cast Magnesium Alloy, Front Engine Covers"
Dr. Alan P. Druschitz and Eric Showalter, INTERMET Corporation
A number of new magnesium casting alloys for high temperature applications are available. However, there is little published data from the testing of actual components. In this study, the castability, mechanical properties (tensile) and component performance (fastner/attachment point acceptability, bracket thread integrity, bracket distortion, resonance and fatigue durability) of front engine covers made from AZ91D, AJ62x, MRI-153M and aluminum alloy 380 are presented. The data demonstrated that bolt load compressive stress retention is a key area that needs to be addressed.

"Development of Intrinsic and Empirical Data for Proper Material Selection for Cam and Rocker Cover Applications"
Mike Dierks, Scott P Meyer, Jim Doty, Spartan Light Metal Products
Over the years, top-of-engine components and in particular Cam and Rocker Covers have become a hot bed for material competition. Looking under the hood of the myriad of vehicles in any given parking lot, one will find plastic, aluminum, magnesium and even steel Cam and Rocker Covers. This paper will outline both intrinsic and empirical data relevant to material selection in Cam and Rocker Cover applications. The focus of this paper will be on plastic, aluminum and magnesium to the exclusion of steel. Data will be presented comparing these materials in areas most significant to the application. This data can be used to balance the tradeoffs and achieve the best design for each of the materials in question. With an apple-to-apple comparison of data at an intrinsic and empirical level, one will be abel to make and apple-to-orange comparison of optimal designs for each material to the same performance specification. As always value is in the eye of the beholder, however, conclusions will be drawn and presented as to which material is the best overall value.

"Energy Policy: Implications for Vehicle Materials"
Thomas Gross
Continued dependence of transportation vehicles on conventional petroleum-based fuels has potentially serious environmental, security and economic impacts. Therefore, programs and policies that accelerate commercial success of vehicles with higher fuel economy are important and desirable. Research, development, demonstration and deployment of cost-competitive, safe, high-performing lightweight materials could make an important contribution in revolutionary vehicles with substantially higher fuel economy. Investments are needed for development work on competitive types of materials that have potential benefits.

"Audi Hybrid Magnesium Technology - A New Approach to the Lightweight Engine Block"
Dr. J. Böhme, Dipl.-Ing. J. Doerr, Dr. W. Schneider, Dr. B. v. Grossmann, Audi AG; Dipl.-Ing. K.D. Becker, VW Kassel; Dipl.-Ing. M. Fiedler, VW Braunschweig; Dr. U. Bischoff, VW Hannover; Dr. U. Holzkamp, VW Group Research
With this contribution Audi describes how in the future the lightweight material magnesium can also be used in engines subject to extreme loads if special detail design solutions and new creep-resistant alloys are adopted. To compensate for the drawbacks of magnesium, AUDI developed a new crankcase concept in which the magnesium structure is reinforced by targeted local material engineering in critical areas. The result of this development is a compact, multi-functional cylinder insert made of aluminium and incorporated into the magnesium block by a pressure die-casting process. It combines the typical functions needed in the engine block, namely cylinder wall, threads for the mounting of the cylinder head, threads for the mounting of the main bearing caps and water jacket (for engine cooling).

"Magnesium Application in the 7G-Tronic-Gear"
Andreas Barth, Daimler Chrysler
Since May 2003 Mercedes-Benz has been equipping several classes with the new 7 G-TRONIC automatic transmission with an outstanding performance such 7 gears, higher torque-carrying-capacity and reduced fuel-consumption. Although the transmission has increased torque-forces, Mercedes-Benz applies for the first time a Mg-die-casting gear-case and Al-bolts. In comparison to a common Al-gear-case with conventional steel-bolts the weight-save is 2,9 kg (6,5 lbs). DaimlerChrysler developed a new Mg-die-casting alloy AS 31 HP, which has a good cast-ability, corrosion-performance, heat-stability and a high dynamical strength due to its high ductility. The corrosion-resistance of Mg-parts can be improved by the use of special die-casting-lubricants. As Mg expands thermally higher than steel, the retention loss of steel bolts during drive-application is unacceptable. Therefore Al-bolts with a similar thermal expansion as the Mg-gear-case are used. The high ductility of AS 31 HP requires certain mechanical machining-parameters. Cost-saving and process-stable recycling-concepts for Mg-residuals deriving from the die-casting and mechanical machining were worked out.

"Use of Magnesium in Structural Crashworthiness Applications"
Arun Kumar and Eric Nelson, Altair Engineering Inc.; Tim Hubbert, Lear Corporation
In this paper, the authors demonstrate the use of magnesium in structural crashworthiness applications. The authors present the development of a die-cast structural magnesium instrument panel (IP) beam for an OEM company. Unlike traditional IP beams in service today, this magnesium IP beam participates in automotive crash events (such as FMVSS 208 and IIHS). The magnesium IP beam is a major load path and withstands a significant amount of crash loads during a crash event. Full-vehicle LS-Dyna simulations were performed to evaluate the magnesium IP beam performance in several crash scenarios. Test results from component testing performed on the magnesium IP beam structure is presented in this paper. Besides, the correlation established between the test results and simulation results is also presented here. Our experience developing this magnesium application demonstrates that magnesium is an excellent material for use in structural applications.

"Prototyping Strategies for Magnesium Die-Castings"
Thomas Ruden, Doug Finkhousen, and Carlos Engel, Lunt Manufacturing Co., Inc.
Since the early 1900's magnesium die-castings have been used in a wide bariety of structural applications in various markets the world over. Magnesium die-castings have found their way into uses where its physical properties are of primary importance, to statically-loaded applications such as covers, enclosures and housings, and for dynamically-loaded applications such as flywheels, automotive steering wheels, cross-car beams (I/P's) and seating structures. And through the years, each die-casting application has gone through the prototyping and development process.

To engineers who specify magnesium die-castings for their products for the first time, in some cases it may not always be clear what prototyping options are available – and which one's are the most useful. In order to help bridge this information gap, this paper reviews the many alternatives available for prototyping magnesium die-castings. Additionally, the paper considers the performance needs of prototypes (physical, static and dynamic) and presents alternate strategies that engineers can adopt for their prototype process.

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"Elektron 21 - A New Aerospace Magnesium Alloy"
Paul Lyon and Dr. Tim Wilks, Magnesium Elektron
Sand cast magnesium alloys have been used in aerospace applications for many years, and a series of new alloys has steadily improved the temperature-property envelope. However most of these alloys have poor corrosion performance and so are deemed not suitable for new applications.

The development of yttrium containing alloy Elektron WE43 by Magnesium Elektron sort to produce a high performance alloy with good corrosion performance. This was achieved, but the alloy can suffer from casting difficulties if strict operational parameters are not adhered to. This can have an adverse impact on part cost.

To overcome these problems, Magnesium Elektron has developed a new magnesium alloy Elektron 21, with properties and corrosion performance close to Elektron WE43 whilst having a much improved founding characteristic. This paper will compare and contrast the performance of the new alloy with the historic alloys.

"Semi-Solid Processing of Magnesium Alloy Components"
S.E. LeBeau, M.W. Walukas, R.F. Decker, Thixomat, Inc.
Lightweight construction using magnesium is in competition with lightweight construction using aluminum, plastics, or steel. Semi-solid processing of magnesium alloys provides the opportunity to adjust the microstructure of magnesium alloys to optimize their performance for the high temperature and structural requirements demanded by the automotive industry. A comparison of three distinct process methods to produce SSM magnesium components, namely, the billet reheating or thixocasting, slurry-on-demand or rheocasting, and injection molding or Thixomolding® is presented. The traditional thixocasting, or billet reheating process, is gaining little commercial acceptance to magnesium alloys due to the unfavorable economics tied to this multi-step process. The newly developed slurry-on-demand methods are described with a renewed interest being displayed on these alternative SSM processes. The ability to use normal foundry metal and the potential for recycling process waste is driving the economics of these processes to a more favorable position. The current commercial status of Thixomolding® is presented along with recent focused efforts on the production of magnesium structural components via Thixomolding®. Studies on fatigue and high temperature alloy creep properties for Thixomolded® components are reviewed. Development of hot runner systems is presented along with recent improvements in Thixomolding® equipment by the machine builders. The projected increases in magnesium consumption in automotive applications can only be accomplished through a cooperative development effort, on an international level, between the automotive OEM producers and their supplier base. Only by adopting an integrated approach that includes the elements of design, prototyping, modeling, improved magnesium alloy development and improved manufacturing processes can the forecasts for magnesium be achieved. The projected increases in the use of magnesium can only be accomplished by a rigorous process of bringing together the entire spectrum of engineering skills involved in bringing new products to market.

"The NIST/ATP Program on Cost Reduced Magnesium Die Castings Using Heated Runners"
Naiyi Li, Ronald P. Cooper, Raymond M. Silva and James E. deVries, Ford Motor Company; Nanda Gopal, Intermet Corp.; Christopher W. Lee, Synventive Molding Solutions; Craig Nelson, IdraPrince Inc.
Magnesium is increasingly becoming an attractive alternative to steel, aluminum, and polymer composites for vehicle weight reduction due to its ability to meet vehicle performance requirements. During the last decade, the magnesium foundry industry has grown rapidly, however the material and manufacturing process costs of magnesium die-casting has impeded large-scale implementation into the automotive industry. As a result, Ford Motor Company initiated a Cost Reduced Magnesium Die Castings Using Heated Runners (CORMAG) program in partnership of the Advanced Technology Program (ATP) of the National Institute of Standards and Technology (NIST). The CORMAG program's goal is to develop low-cost magnesium die-casting technology for structural automotive applications to achieve improved quality and productivity, and low-cost die-cast components. This paper presents an overview of the CORMAG program. It also depicts advanced manufacturing technology developed and provides technical results based on a mule casting produced from AM60B alloy.

"New Continuous Casting Process for Magnesium Alloys"
Dipl.-Ing. Stefan Schacht, Dipl.-Ing Michale Gummert, Prof. Dr.-Ing. Friedrich-Wilhelm Bach, Institute for Materials Science, Univeristy of Hanover

Compared to pressure die casting components, formed parts made of magnesium alloys exhibit an up to 100% higher strength and an up to 150% higher ductile yield. Despite the relatively poor material exploitation , most magnesium alloy components are currently made by pressure die casting in the automotive and other industries. Apart from problems like deficient knowledge about adapted processing technologies for extruding, rolling and forging Magnesium alloys, supply with semifinished products for forming processes is difficult for magnesium alloys today. Continuous casting is the key technology for cost effective manufacturing of semifinished products. Specific properties of magnesium alloys causing problems in continuous casting process, particularly the fact that the melts tend to burn when exposed to air and the very low strengths at elevated temperatures. Developed in an EC-contributed project, a new continuous casting process was designed exclusively to cast magnesium alloys. The vertically upwards billet discharge direction is the basic feature of this method, allowing a solidification process with no contact to atmosphere and producing high purity cast billets.

"Integrated Process Chain for Automobile Magnesium Sheet Components"

Peter Juchmann, Salzgitter Magnesium-Technologie GmbH

Due to their outstanding property profile Magnesium flat rolled products represent an attractive material for new ultralight constructions. This is especially valid for large thin-walled automobile components as well as for high performance machines or electronic equipment. The growing interest for Magnesium sheet results from continuous quality improvements and a better availability of semi-finished products. The technical and economical competitiveness is closely related with a further optimising of the process chains of Magnesium wrought alloys.

Salzgitter Magnesium-Technologie GmbH in Germany concentrates on the development, production, processing and trading of new, high quality Magnesium flat rolled products. The company offers a complete technology and material partnership ranging from product development to series applications.

The presentation focuses on Mg-sheet products and gives an overview of a joint research project of Salzgitter Magnesium-Technologie GmbH, Volkswagen AG and other partners developing ultralight Mg-sheet components for auto-body structures.

"Alternatives of SF6 for the Magnesium Processor - A Technical, Environmental and Economic Assessment"

Gabriella Tranell, SINTEF Materials and Chemistry

In response to increasing global awareness and legislation regarding green house gas emissions, the International Magnesium Association initiated a research project in the year 2000, aimed at finding alternatives to SF6 for melt protection in the Magnesium industry. The research project was carried out by SINTEF in Norway and focused both on investigating the fundamental mechanisms of melt protection, as well as industrial scale testing and bench-marking on new and proposed SF6 replacements. This paper summarizes some of the key technical findings of the industrial scale testing of SF6 alternatives and subsequently attempts to make an objective comparison of the technical, environmental and economic performances of HFC 134-a, HFE 7100 and Novec 612, as SF6 replacements.

"Capture & Recycle for Emission Reduction of Sulfur Hexaflouride in Magnesium Casting"

Tom Tripp and Joe Fox, US Magnesium; John Barney, Air Liquide America

A partnership in 2000 between US Magnesium (MagCorp) and Air Liquide was formed to develop and test the potential of reducing sulfut hexafluoride emissions from magnesium casting operations via gas recycling based on membrane technology processes. Air Liquide has developed a Floxal SF6 Recycle Process, which is capable of capturing dilute SF6 in the parts per million (ppm) range from the casting system exhaust and recycle it as a concentrated geed gas in percentage levels. This process utilizes proprietary membrane technology to separate the SF6 from air in four stages: pretreatment, compression, separation and recycle.

"Use of SO2 as Protection Gas for Mg Recycling"

Guenter Franke and Dr.-Ing. Juergen Schlimbach, Norske Hydro

Different protection gases are used to protect liquid magnesium metal. Most of them are containing fluoride except sulfur dioxide. Mixing with carrier gases is possible in different concentration of the protection gas, depending on produced alloys and equipment used.

The most used protection gas today is SF6, unfortunately this gas has a very high global warming potential and the magnesium industry is one of the largest emitter. Due to the high GWP in future production and use will be restricted or forbidden. Alternative cover gases are offered, also containing fluoride but with lower GWP compared to SF6. Some of them have been tested at different companies with all kind of magnesium alloys. During reaction with the magnesium melt other gases can be generated with a global warming potential. The generation of HF is possible, too.

"The Protection of Molten Magnesium by SO2 Gas Mixtures"

Karin Renger, ARC LKR; Andreas Büker, Heinz Schulte Rosier, ASKI Gasetechnik GmbH

Molten magnesium oxidizes rapidly in air and starts to burn. Magnesium oxide formed on the surface of molten magnesium is not able to prevent further oxidation of the magnesium and the vaporization of magnesium. This is due to the fact that the molar volume of magnesium oxide is smaller than the molar volume of magnesium (Pilling-Bedworth ratio [1]). This problem can either be solved by using salt fluxes and/or protective gas atmospheres. The use of salt fluxes can lead to salt contamination and reduce by this the corrosion resistance of the magnesium products. Furthermore use of flux increases the melt loss. Therefore most die casters prefer fluxless protection.

"AM-Cover: A Production Proven SF6 Replacement for the Magnesium Die Casting Industry"
Rob Bailey, Australian Magnesium Corp. Ltd.; Nigel Rickets, CSIRO
With the challenge in the late 1990's of developing a replacement cover gas technology which performs as well as SF6 and substantially reduces greenhouse gas emissions, Australian Magnesium Corporation (AMC) and the CRC for Cast Metals Manufacturing (CAST) have developed AM-cover, which uses HFC-134a as the active gas. Greenhouse gas emissions have been reduced by over 95%, as compared to normal usage of SF6 cover gas mixtures. This paper summarizes experience with the use of AM-cover in the production of over 1.25 million pounds of magnesium die castings in North America in the 10 month period from April 2003 through to the end of January, 2004